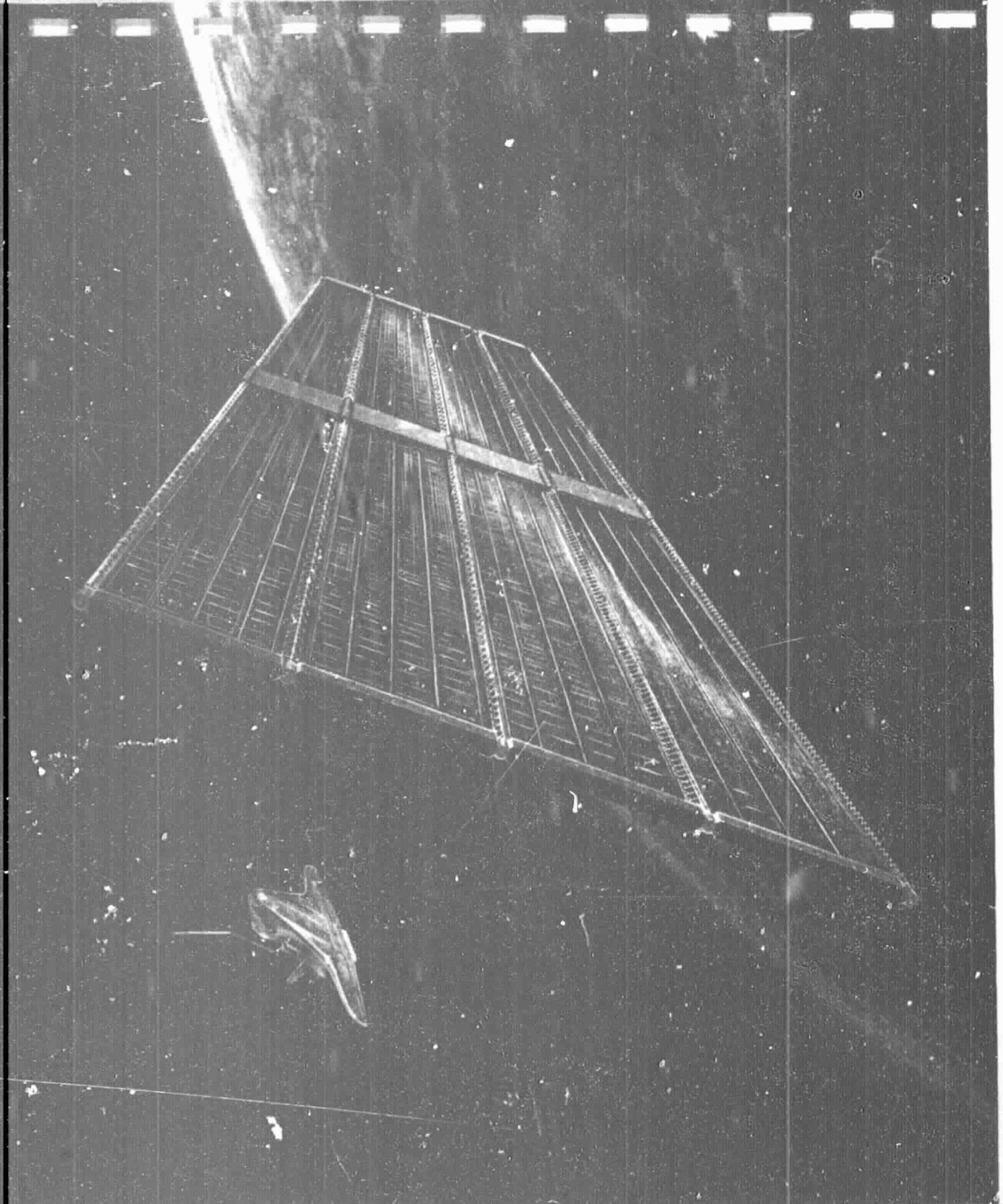


Final Review

June 1982

Multi -100 kW

Planar Low Cost
Solar Array Development

submitted to:

NASA

MARSHALL SPACE FLIGHT CENTER
National Aeronautics and Space Administration

Lockheed

MISSILES & SPACE COMPANY, INC.
SUNNYVALE, CALIFORNIA

(NASA-CR-162067) MULTI-100 KW: PLANAR LOW COST SOLAR ARRAY DEVELOPMENT Final Review Report (Lockheed Missiles and Space Co.) 45 p HC A03/MF A01

N82-31340

Unclas

G3/15 28823

Multi 100 kW
Final Review

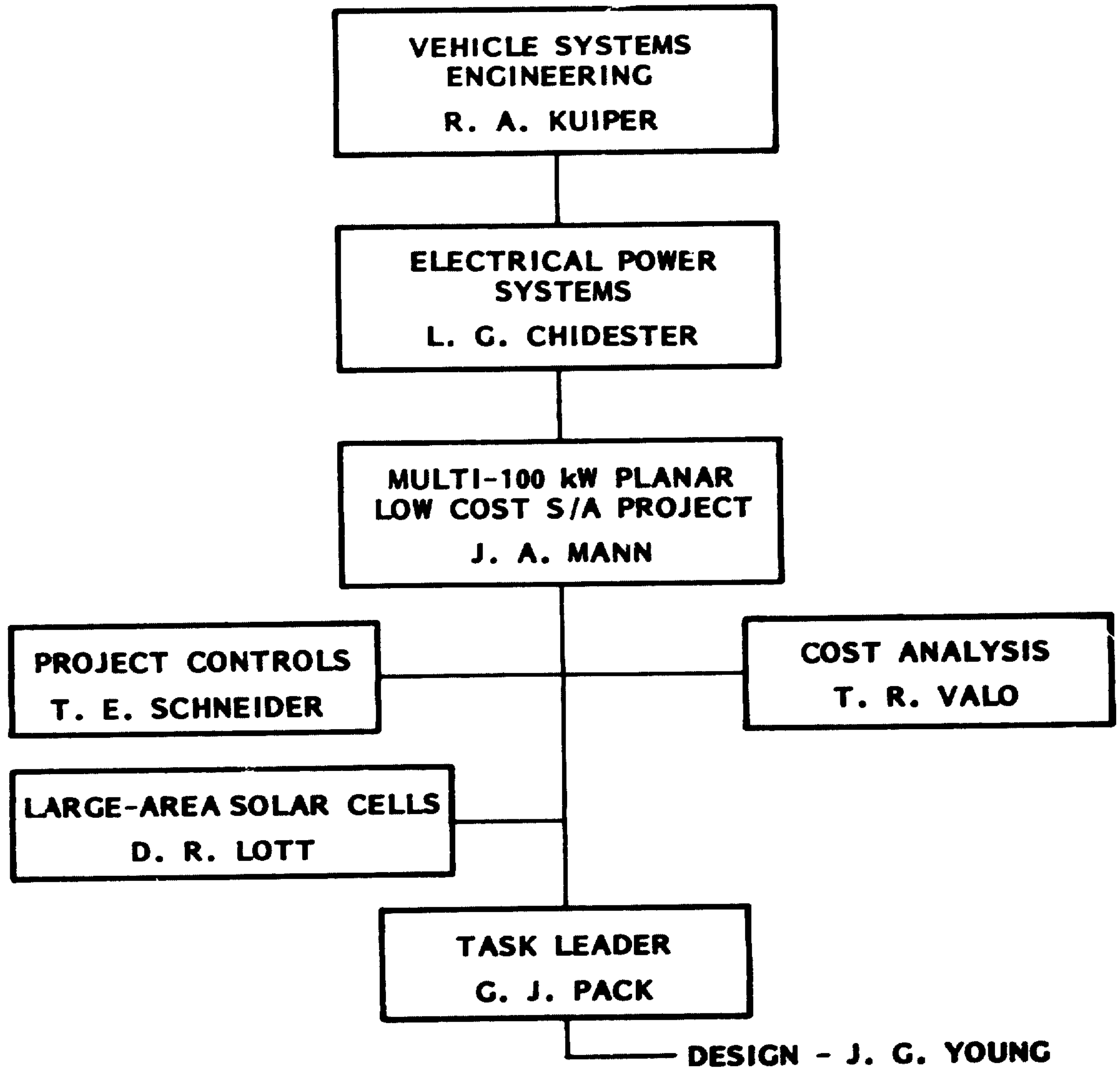
NASA

FINAL REVIEW

AGENDA

• INTRODUCTION AND TASK DEFINITION	J. MANN
• TASK 1	J. MANN
– SIMPLIFIED CELL SPECIFICATION REVIEW – CELL PROCUREMENT – LARGER CELL DISCUSSION	
• TASK 2	G. PACK
– MODULE FABRICATION – CELL AND MODULE TEST RESULTS – 30-CELL SUPERSTRATE RESULTS	
• CONCLUSIONS	G. PACK
• RECOMMENDATIONS	J. MANN

PROJECT ORGANIZATION



MULTI-100 kW LOW COST PLANAR SOLAR ARRAY OBJECTIVES

TASK 1

- LMSC/CELL VENDOR TO NEGOTIATE SIMPLIFIED LARGE-AREA SOLAR CELL SPECIFICATION
- PURCHASE LARGE-AREA 5.9 x 5.9 cm WRAPAROUND SOLAR CELLS FROM CELL VENDORS REPRESENTING LOW COST ALTERNATIVES
- INVESTIGATE LARGER-AREA CELLS (10 x 10 cm) TO DETERMINE FEASIBILITY OF FURTHER COST REDUCTION

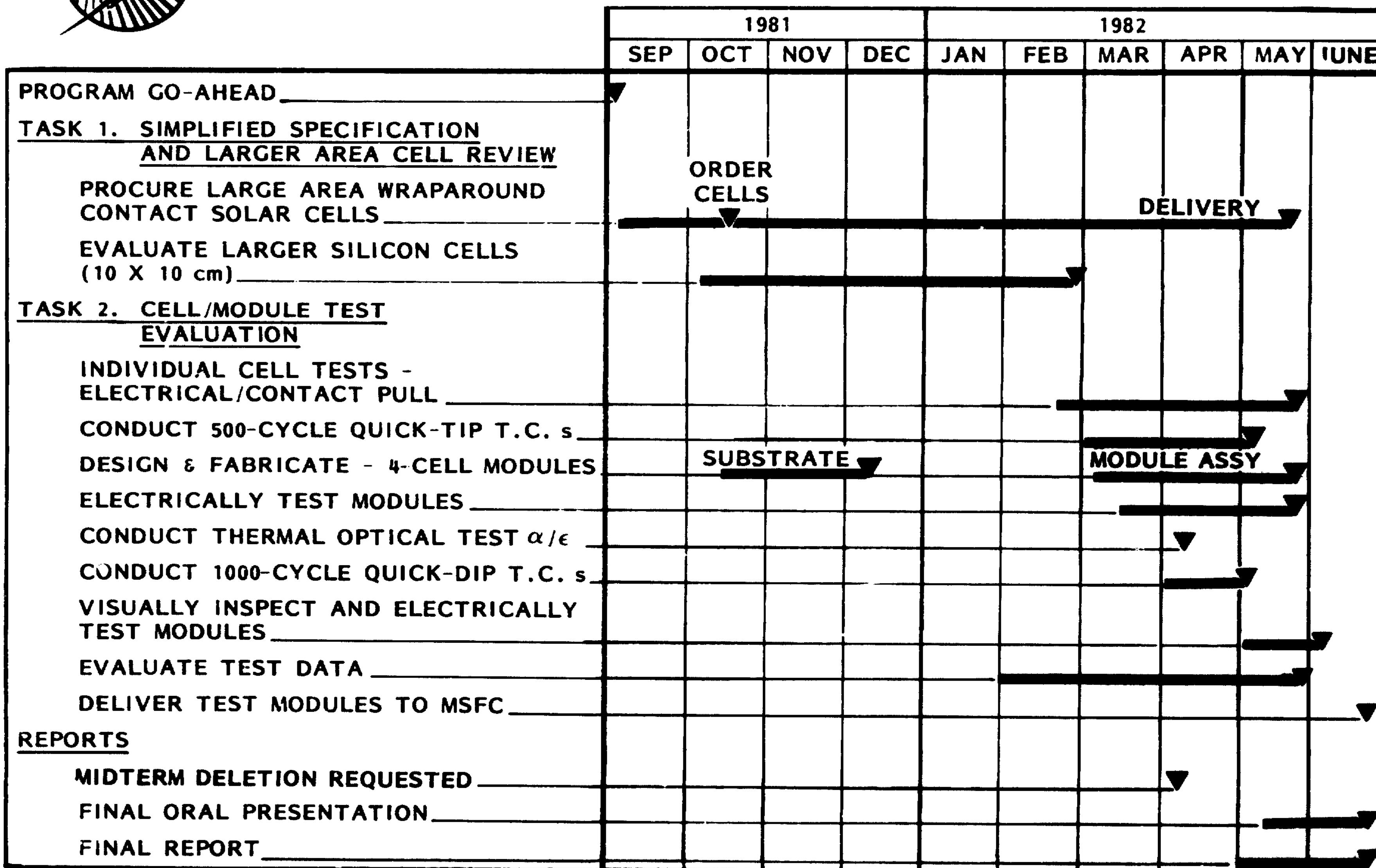
TASK 2

- CONDUCT:
  - ELECTRICAL TESTS - 100%
  - MECHANICAL TESTS - SAMPLE
  - RAPID THERMAL CYCLE TEST - SAMPLE
- FABRICATE: 4-CELL MODULES OF EACH CELL TYPE
- CONDUCT MODULE:
  - ELECTRICAL/OPTICAL TESTS
  - RAPID THERMAL CYCLE TEST
- FABRICATE: 30-CELL SUPERSTRATE MODULE (ADDED)

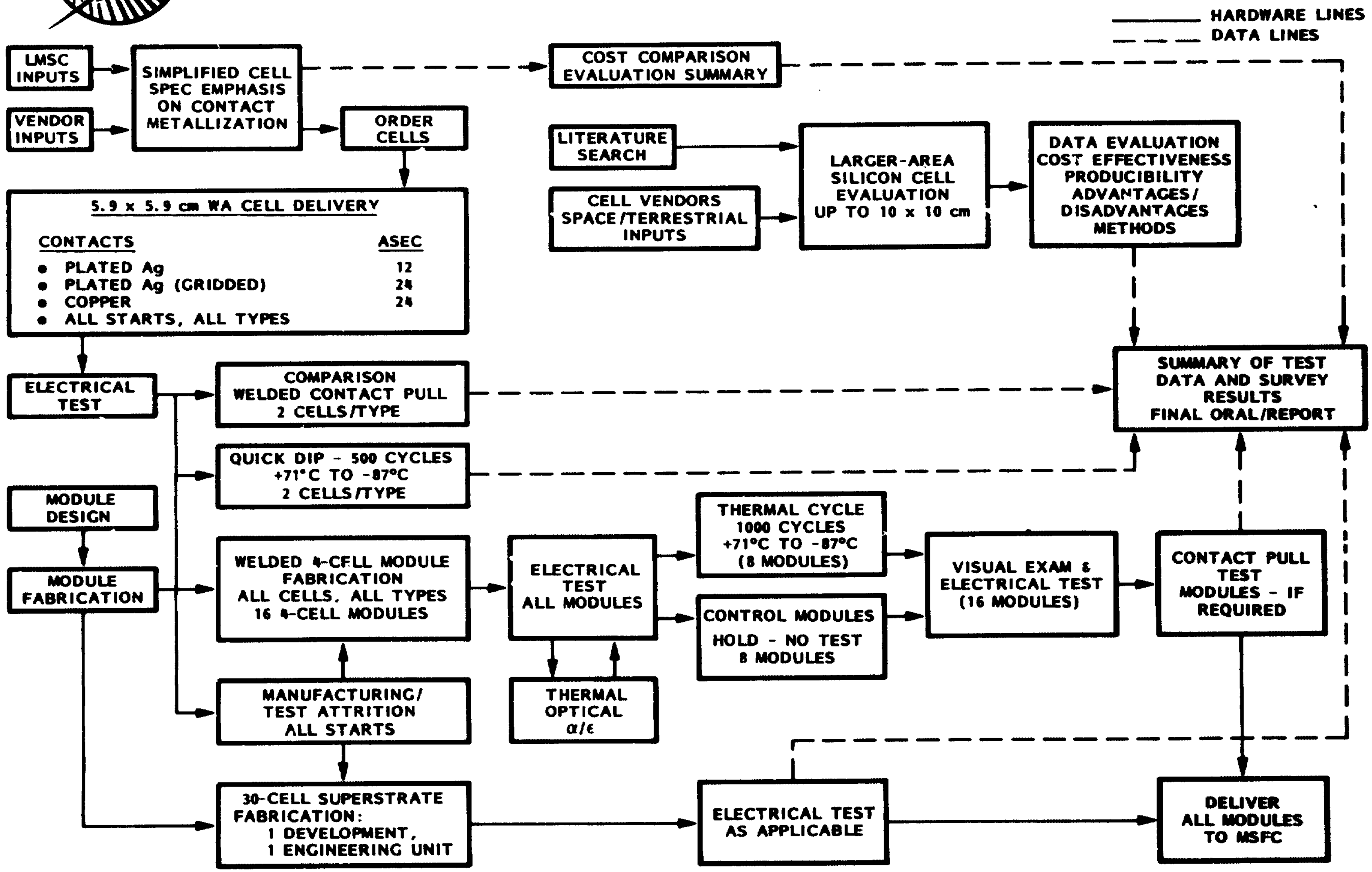
DELIVERABLES:

- FINAL REPORT/ORAL
- HARDWARE - TEN 4-CELL MODULES
  ONE 30-CELL SUPERSTRATE MODULE

MULTI-kW PLANAR LOW COST SOLAR ARRAY SCHEDULE



PROJECT WORKFLOW DIAGRAM



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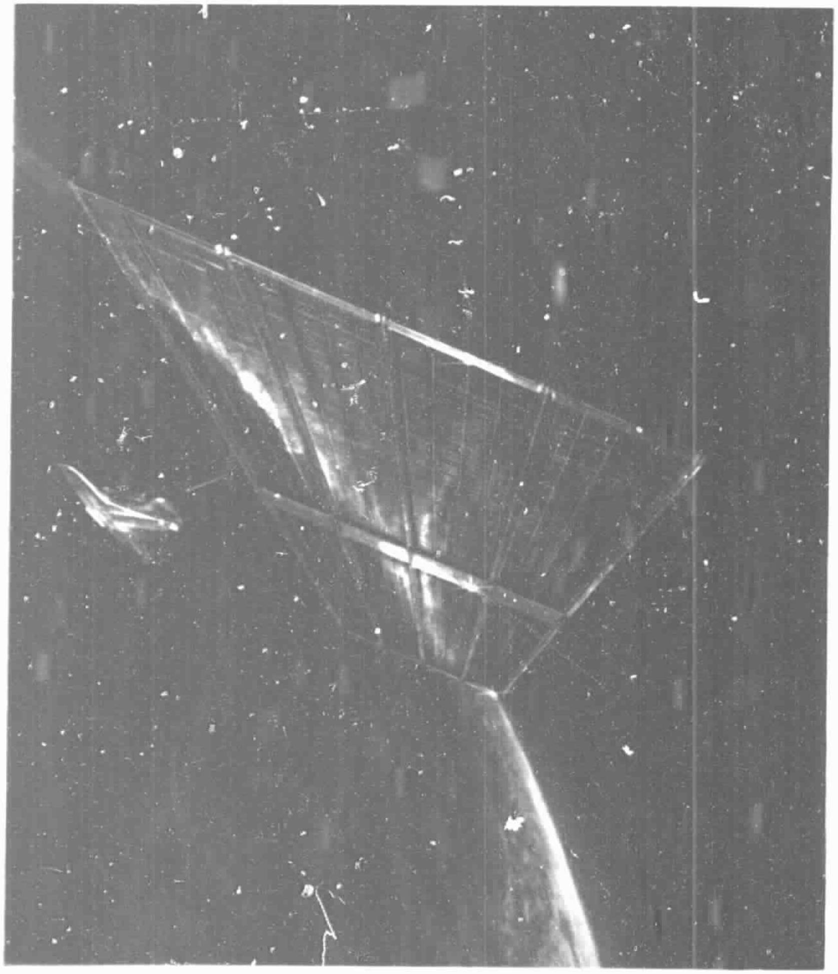
BASELINE MULTI-100-kW PLANAR LOW-COST SOLAR ARRAY



- LEO – SHUTTLE OPTIMIZED
- 64 X 58m
- 427 kW – BOL
- 311 kW – 15–YR AVERAGE
- KAPTON SUBSTRATE ASSEMBLY $\epsilon = 0.80$
- 8 mil, 5.9 X 5.9 cm WRAPAROUND CONTACT SOLAR CELL
- Ti Pd Ag (BACKSIDE GRIDDED) CONTACTS
- 6-mil MICROSHEET SUPERSTRATE 15 X 15 in. SHEETS

TASK 1

- SIMPLIFIED CELL SPECIFICATION REVIEW
- CELL PROCUREMENT
- ELECTRICAL PERFORMANCE COMPARISON
- COPPER CONTACT METALLIZATION SUMMARY
- CELL CONTACT PULL STRENGTHS
- THERMAL-OPTICAL PERFORMANCE
- SUPERSTRATE ADHESIVE DISCUSSION
- SOLAR CELL COST PROJECTION

SIMPLIFIED SOLAR CELL SPECIFICATION

REQUIREMENT OF BASIC SPECIFICATION LMSC-D715825

- TYPE: N-P, WELDABLE/SOLDERABLE DIELECTRIC WRAPAROUND CONTACT
- DOCUMENTATION: GOVERNMENT COVERING: BAGGING MATERIALS, PACKAGING, I.D., SOLDERING, SAMPLING, STANDARDS, HUMIDITY CONTROL
- CONTACTS: EVAPORATED/PLATED AND SINTERED
- BACK-SURFACE REFLECTOR
- CONTACT TENSILE STRENGTH AT 45° PULL ANGLE: 350 gm FOR WELDABLE CELLS AND 600 gm FOR SOLDERABLE CELLS
- CHIPS: MAXIMUM EDGE CHIPS 0.13 cm, DEPTH 0.75; CORNER CHIPS NOT ALLOWED IN RADIUS REGION
- ANTIREFLECTIVE COATING: MULTILAYER
- CONTACT SMOOTHNESS: 200 nm RMS OR LESS
- CONTACT THICKNESS: 6 TO 9μ
- CONTACT DEFECTS: NONE IN AREAS OF ELECTRICAL BOND

SIMPLIFIED SOLAR CELL SPECIFICATION (Cont'd)

- CELL DEFECTS: FREE OF CRACKS, SCRATCHES, LOOSENESS OR PEELING GRIDS, INCLUSIONS, AND RESIDUES
- CRYSTAL ORIENTATION: 1·0·0
- CHEMICALLY POLISHED OR ETCHED TO REMOVE WORK DAMAGE
- PERFORMANCE: DEFINED
- OPTICAL PROPERTIES: $\alpha_s / \epsilon_N \leq 0.90$
- RADIATION DEGRADATION: <10% AT 2×10^{14} e/cm^2
- THERMAL CYCLING: WITHOUT DEGRADATION AFTER 1000 CYCLES FROM +55°C TO -190°C.
- DIMENSION/WEIGHT: DEFINED

ACCEPTANCE TESTS

- EACH CELL INSPECTED FOR DEFECTS AND DIMENSION
- CONTACT PULL STRENGTH TEST
- OPTICAL PROPERTIES: 10 CELLS FROM PRODUCTION
- TAPE TEST: TAPE PEEL FROM BOTH CONTACTS AFTER BOILING WATER--10 CELLS

SIMPLIFIED SOLAR CELL SPECIFICATION (Cont'd)

- TEMPERATURE CYCLE: 1000 CYCLES AND CONTACT PULL STRENGTH IN EXCESS OF 70 gm (20 CELLS)
- CONTACT SMOOTHNESS: 5 CELLS

THIS SPECIFICATION HAS BEEN NEGOTIATED WITH ASEC.

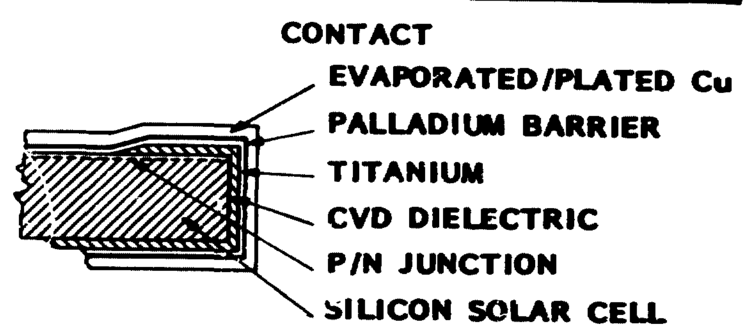
- ADDITION TO THIS SPECIFICATION FOR THE CURRENT CONTRACT

SOLAR CELL PURCHASE SUMMARY

CELL VENDOR: APPLIED SOLAR ENERGY CORPORATION (ASEC)

	BASIC	GRIDDED BACKSIDE CONTACT	COPPER CONTACT
• SIZE (cm)	5.9 x 5.9	5.9 x 5.9	5.9 x 5.9
• CONTACT CONFIGURATION	WA	WA	WA
• BASE RESISTIVITY	2	2	2
• BSR	YES	NO	NO
• BSF	NO	NO*	NO
• WELDABLE	YES	YES	YES
• METALLIZATION		BORON	
EVAPORATION	Al Ti Pd Ag	Ti Pd Ag	Ti Pd Cu
PLATE UP	Ag	Ag	Cu

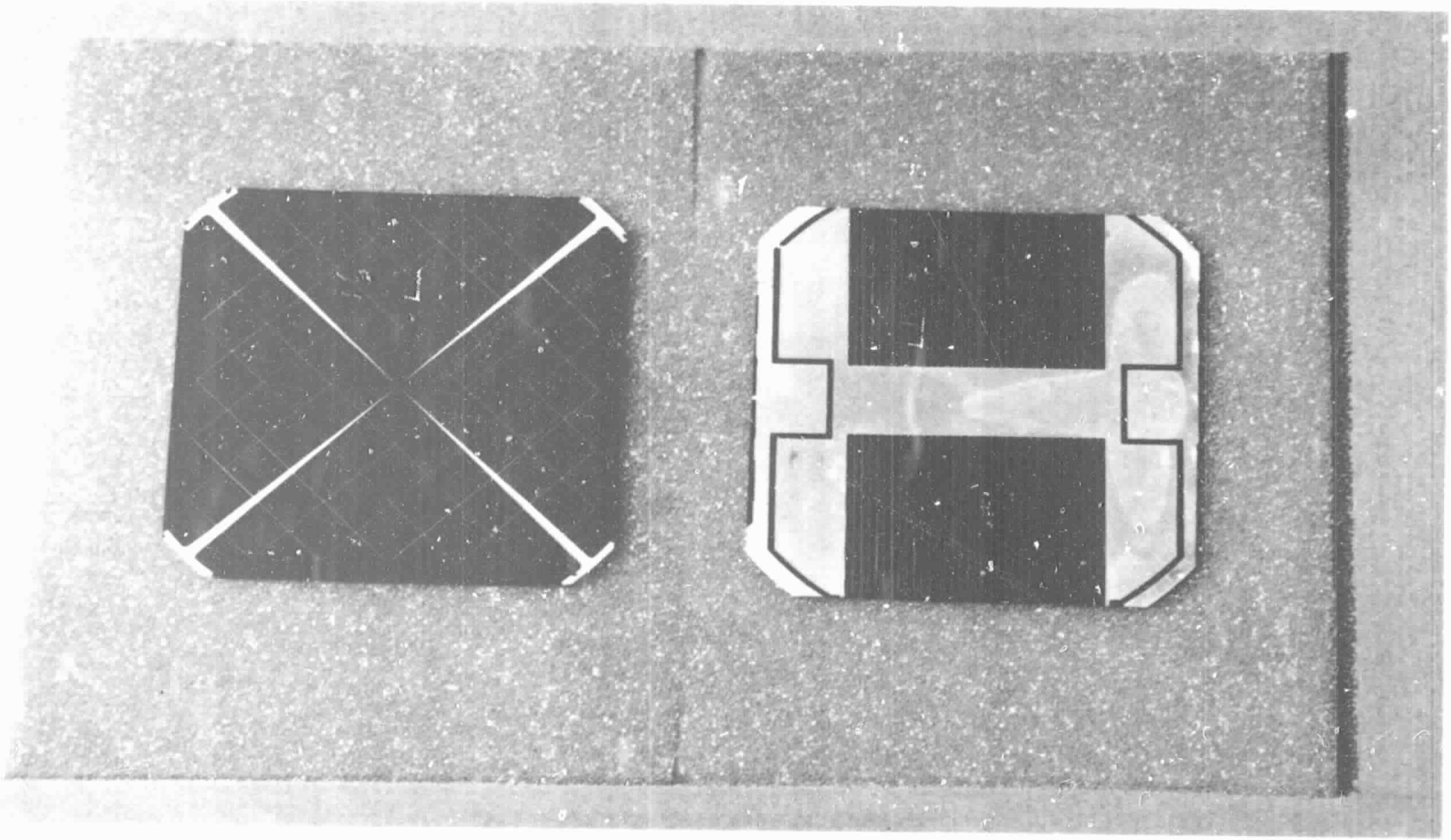
*MINOR BORON DIFFUSION TO REDUCE BACK-SURFACE COLLECTION RESISTANCE



LOCKHEED MISSILES & SPACE COMPANY INC.

5.9 X 5.9 CM DIELECTRIC WRAPAROUND SILICON SOLAR CELL

LARGE AREA WRAPAROUND CONTACT SOLAR CELL GRIDDED BACK CONFIGURATION



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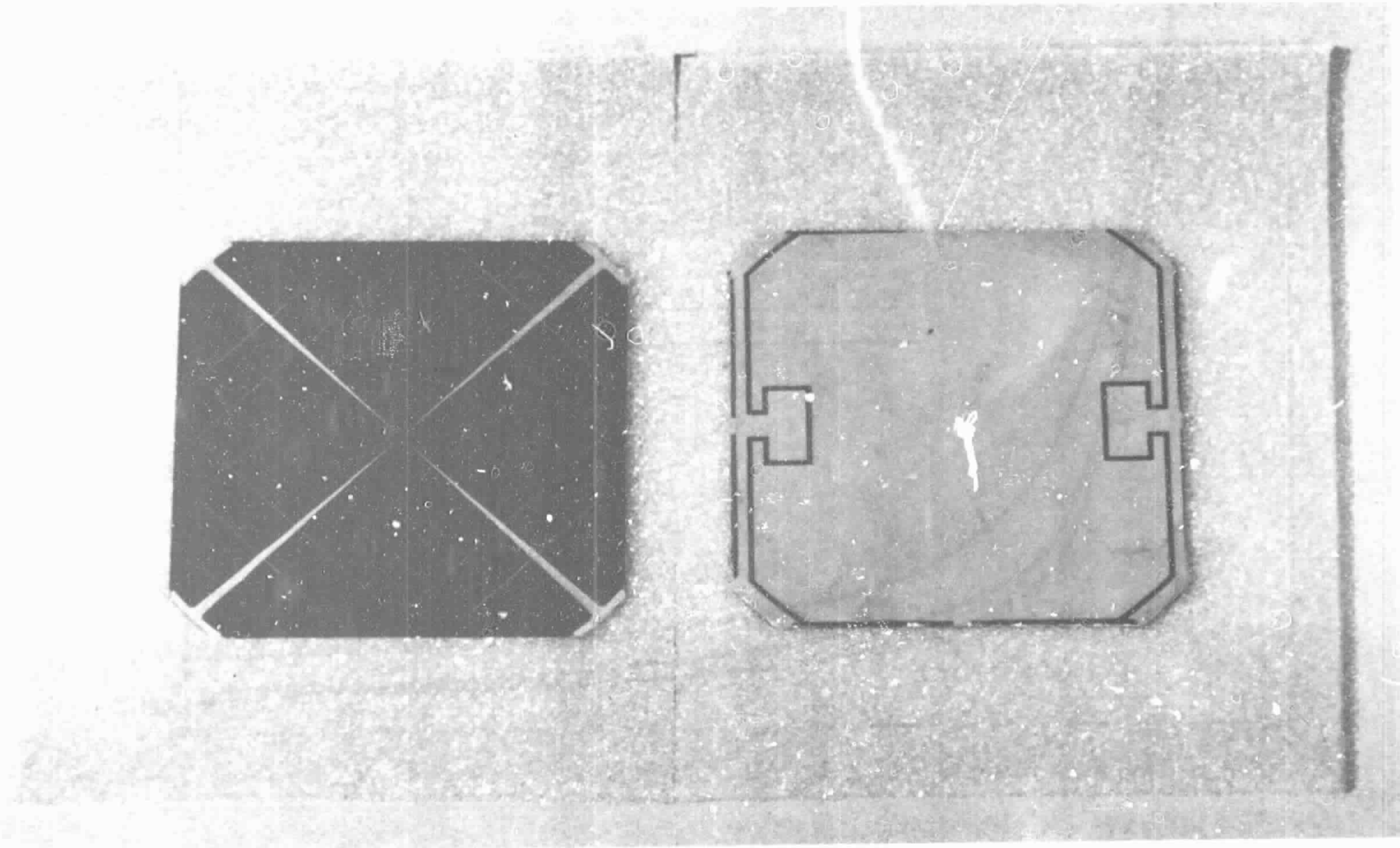
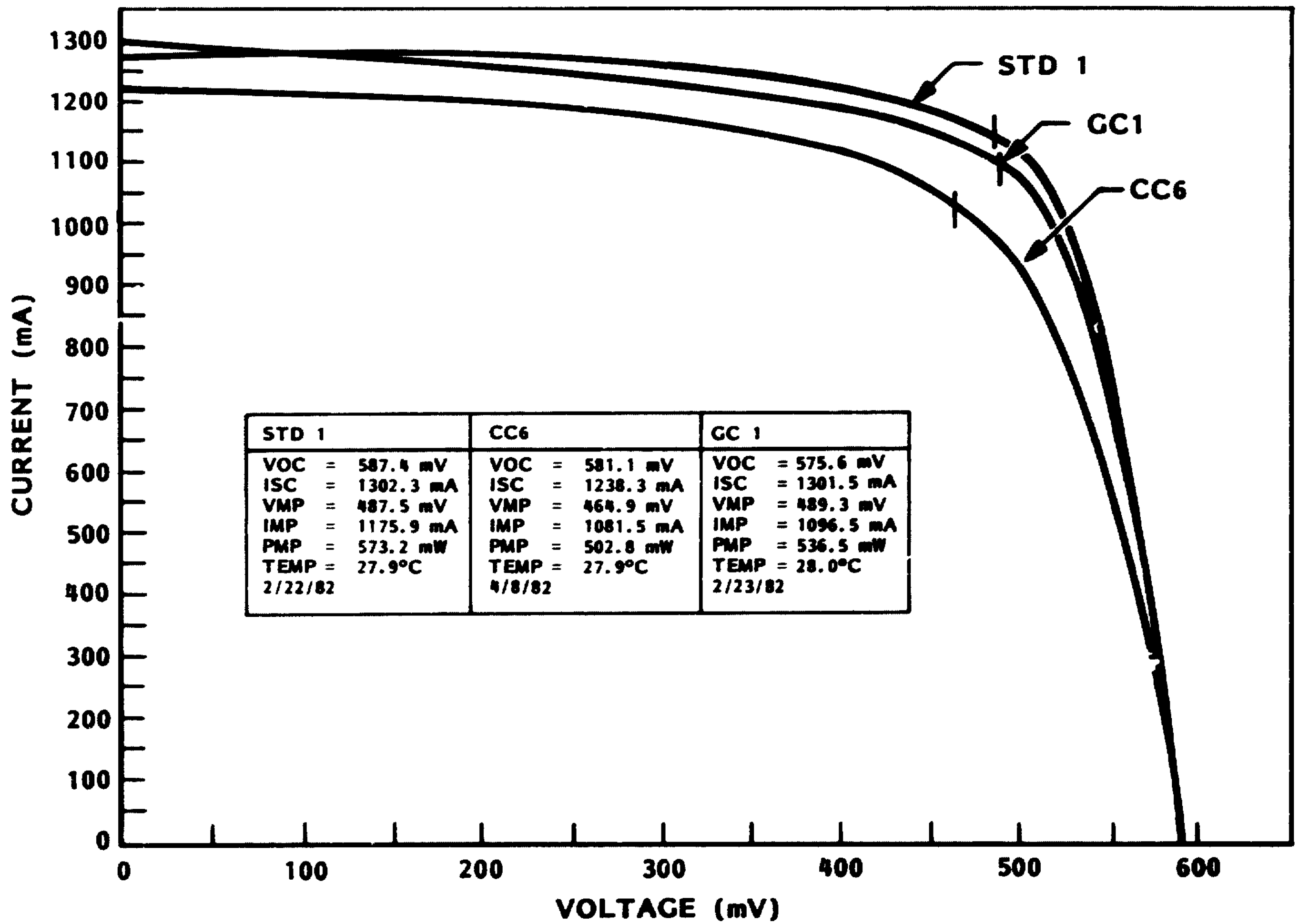
LARGE AREA WRAPAROUND CONTACT SOLAR CELL COPPER METALLIZATION CONFIGURATION



ELECTRICAL PERFORMANCE COMPARISON CURVES



STD 1	CC6	GC 1
VOC = 587.4 mV	VOC = 581.1 mV	VOC = 575.6 mV
ISC = 1302.3 mA	ISC = 1238.3 mA	ISC = 1301.5 mA
VMP = 487.5 mV	VMP = 464.9 mV	VMP = 489.3 mV
IMP = 1175.9 mA	IMP = 1081.5 mA	IMP = 1096.5 mA
PMP = 573.2 mW	PMP = 502.8 mW	PMP = 536.5 mW
TEMP = 27.9°C	TEMP = 27.9°C	TEMP = 28.0°C
2/22/82	4/8/82	2/23/82

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COPPER CONTACT METALLIZATION SUMMARY

OBJECTIVE: TO SUBSTITUTE COPPER FOR EXPENSIVE SILVER CONTACT METALLIZATION

CELL VENDOR RESULTS:

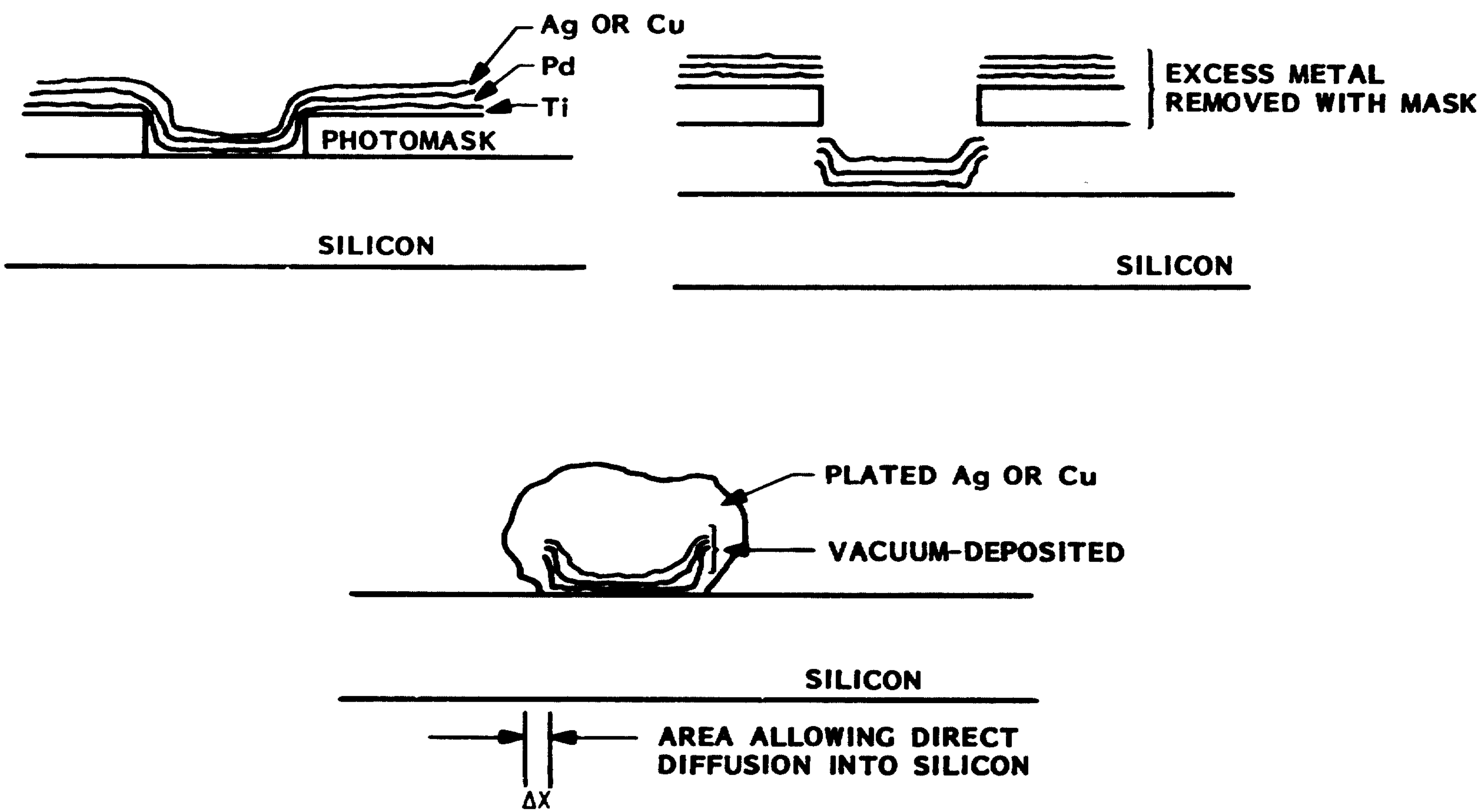
- COPPER HAS SEVERE TARNISHING PROBLEM THAT MAY REQUIRE PROTECTIVE COATING
- BARRIER METAL REQUIRED BETWEEN COPPER AND SILICON
- WITHOUT BARRIER OR WITH POOR BARRIER (HOLES) COPPER WILL MIGRATE INTO SPACE CHARGE REGION (N CONTACT SIDE) AT HEATS BELOW SINTERING TEMPERATURE
- BARRIER METALS TRIED – Ti, Pd, Ni. TO FORM METAL SILICIDE
- COPPER ELECTROPLATED ON NARROW GRIDS MUSHROOM OVER INTO SILICON CONTACT
- REVERSE ETCHING ATTEMPTED TO AVOID MUSHROOMS
- COPPER EVAPORATION IS VERY SLOW COMPARED WITH SILVER
- COPPER PLATE UP AFTER Ti-Pd-Cu EVAPORATION SHOWED SIGNS OF SiO_2 DIELECTRIC, PARTICULARLY ALONG EDGES, BEING ATTACKED BY THE BATH SOLUTION, THUS COPPER PENETRATION OF THE SPACE CHARGE REGION.
- EVAPORATED Ti-Pd-Cu SINTERED, THEN Cu PLATED IMPROVED YIELD

COPPER CONTACT METALLIZATION SUMMARY (Cont)

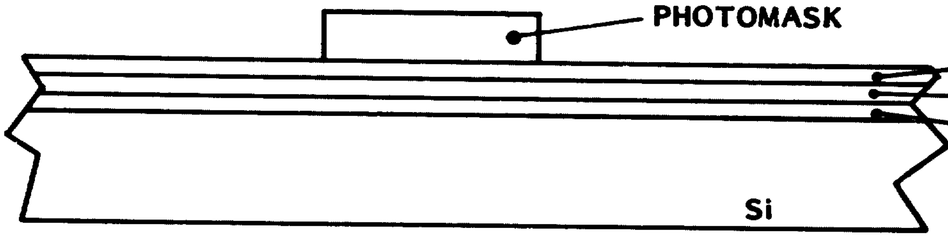
CONCLUSIONS:

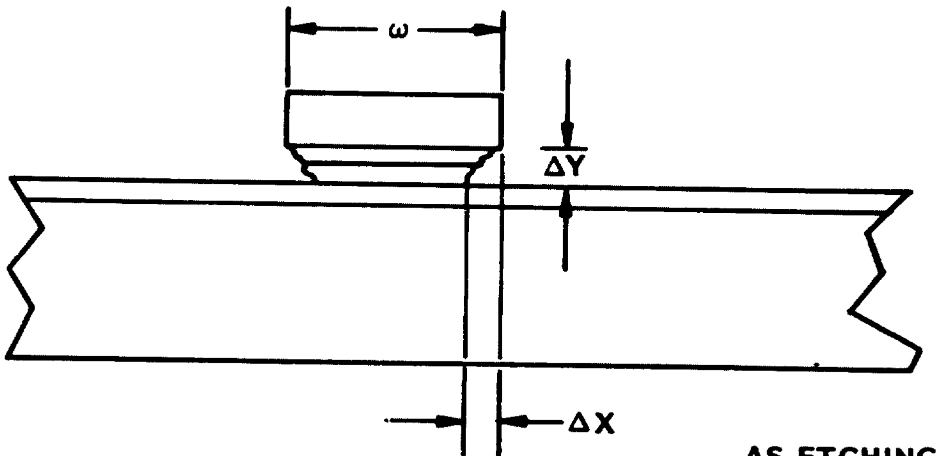
- BASIC PROCESS SHOULD BE DEVELOPED ON CONVENTIONAL CELL WITH LESS COMPLEX AND FINE GRID PATTERNS BEFORE ATTEMPTING WRAPAROUND CONFIGURATION.
- DEVELOP IMPROVED METAL SILICIDE BARRIER LAYERS
- DEVELOP MEANS OF PLATING NARROW COPPER GRIDS WITHIN BARRIER LAYDOWN
- EVALUATE DIELECTRIC MATERIALS IMPERVIOUS TO COPPER BATH SOLUTIONS.

CONVENTIONAL ETCHING PROCEDURE



REVERSE ETCHING PROCEDURE



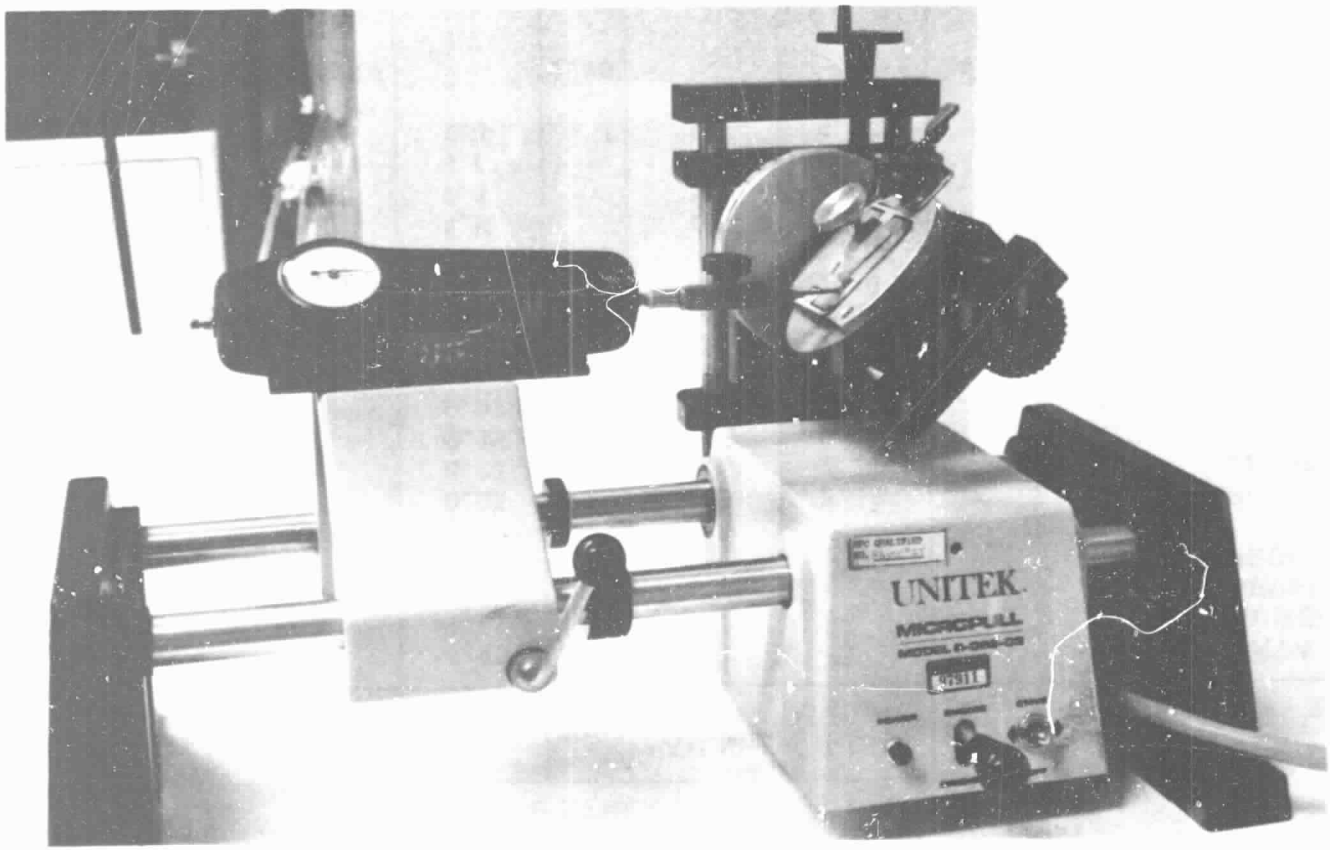


AS ETCHING PROCEEDS

$\Delta X \simeq \Delta Y$

IF $\Delta X \times 2$ BECOMES A SIGNIFICANT FRACTION OF ω, GRIDLINE WILL SEPARATE

CONTACT PULL STRENGTH TESTER



CONTACT PULL STRENGTH COMPARISON

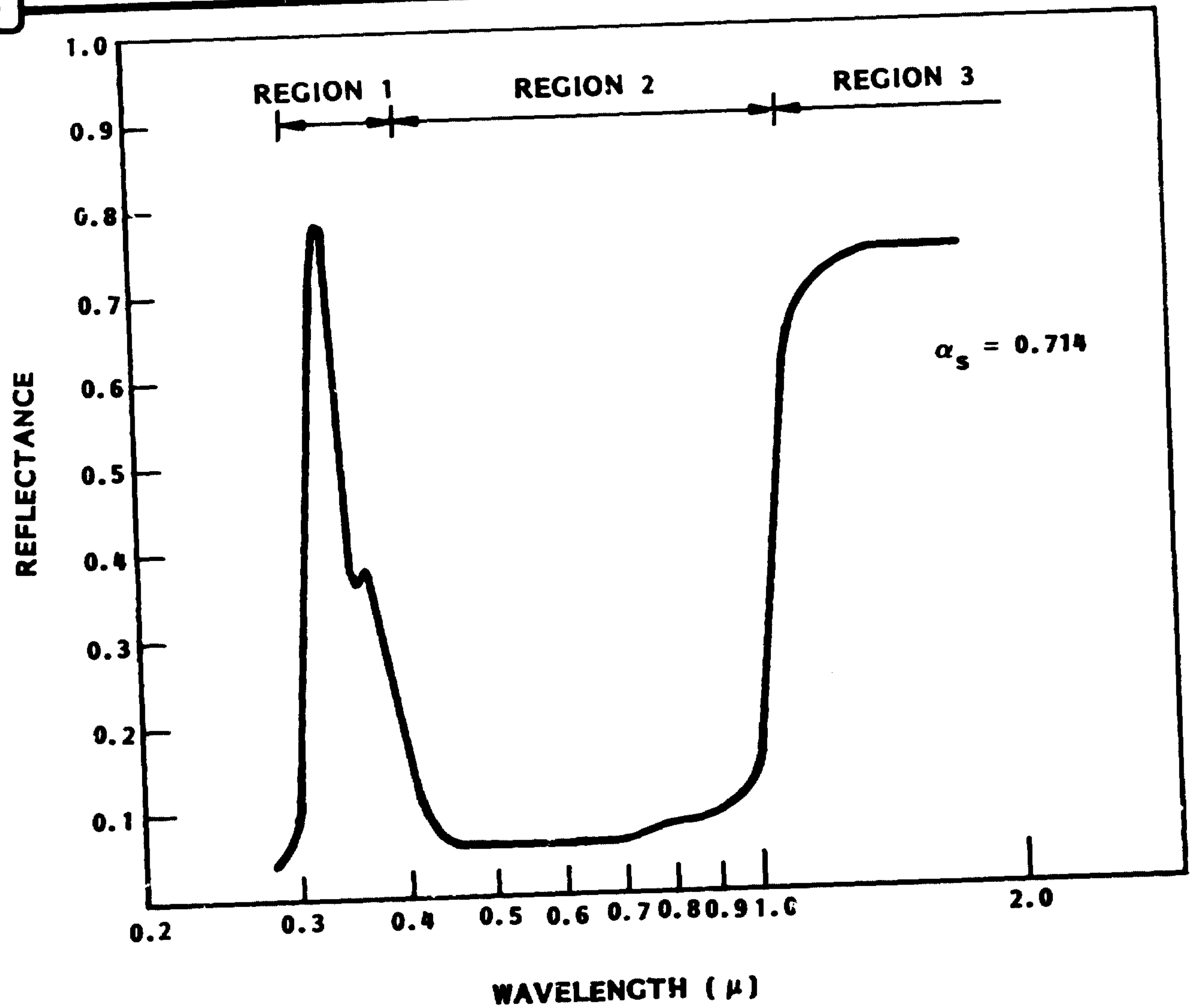
CELL DESCRIPTION	N CONTACT PULL STRENGTH INDIVIDUAL	N CONTACT PULL STRENGTH AVG	N CONTACT PULL STRENGTH FAILURE MODE	P CONTACT PULL STRENGTH INDIVIDUAL	P CONTACT PULL STRENGTH AVG	P CONTACT PULL STRENGTH FAILURE MODE	COMMENTS
(1) BASELINE 5.9 cm WA CELL CONTINUOUS BACK CONTACT Ti-Pd-Ag	1.45 1.69	1.57					DATA FROM LMSC ID WELD DEVELOPMENT PROGRAM
(2) GRIDDED Ti-Pd-Ag BACK CONTACT 5.9 WA CELL	0.35		MF	2.35		CT	PULL STRENGTH IN LB/WELD JOINT
	0.22		MF	2.25		CT	
	0.35		MF	2.10		CT	
	0.07		MF	2.30		CT	
		0.25			2.25		
	2.0		CB	2.10		CB	
	1.5		MF	2.00		CB	
		1.75		2.20		CT	
					2.10		
(3) COPPER CONTACT 5.9 cm WA Ti-Pd-Cu	4.5		CT	4.0		CT	PULL STRENGTH IN LB/SOLDER JOINT
	1.1		MF	4.0		CT	
	3.0		CT	4.3		CT	
	1.0		MF	4.5		CT	
		2.40			4.2		
	4.25		CT	4.25		CT	
	3.50		CB	4.00		CT	
	3.8		CB	4.30		CT	
	2.0		CB	4.30		CT	
		2.9			4.2		

NOTE: MF = METALLIZATION FAILURE
CT = COPPER PULL TAB FAILURE
CB = CELL BROKE

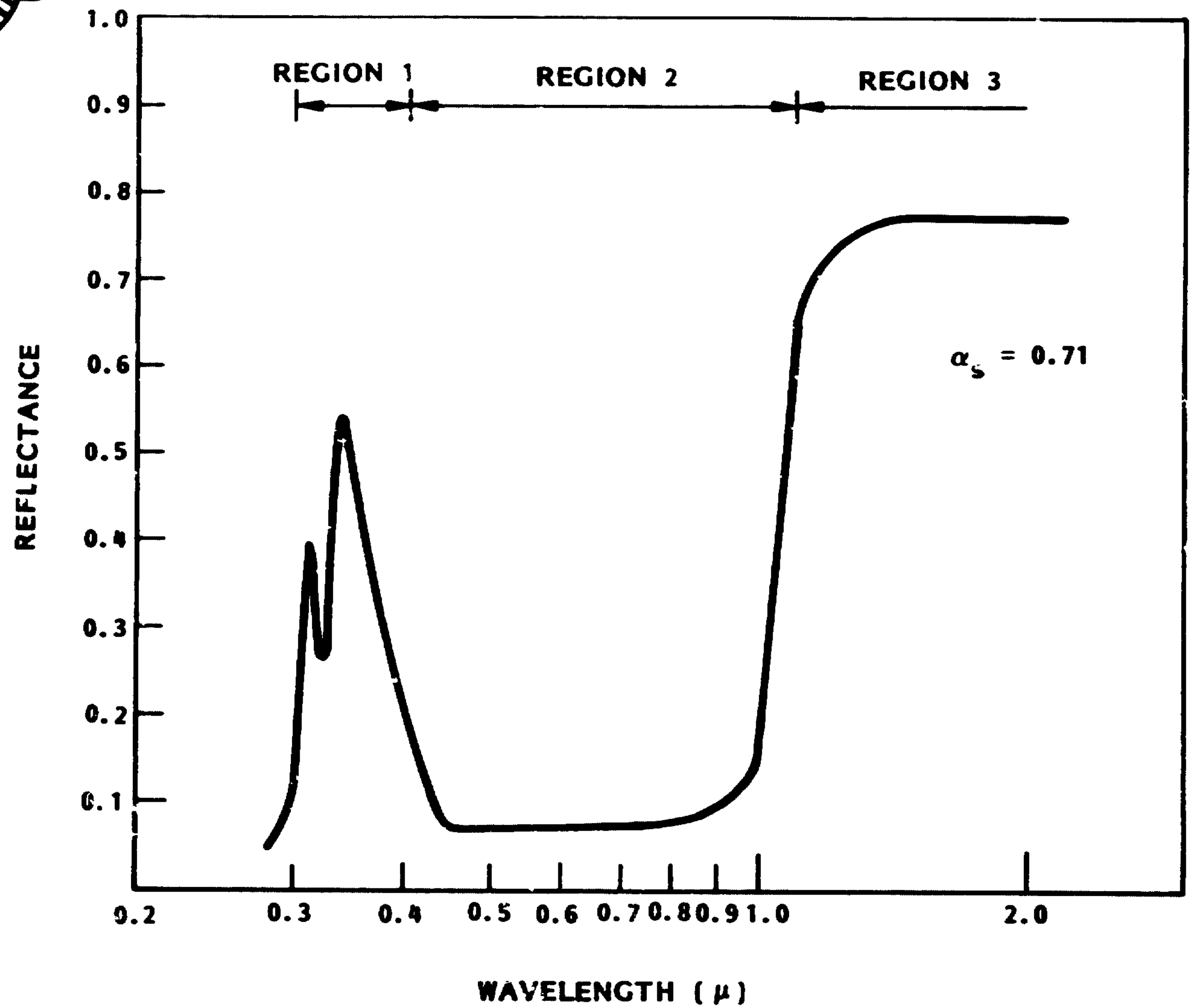
WELD SCHEDULE

WELD VOLTAGE = 0.63V
IR SETTING = 4.07
ELECTRODE FORCE = 2.0 LB
ELECTRODE GAP = 0.012 IN.

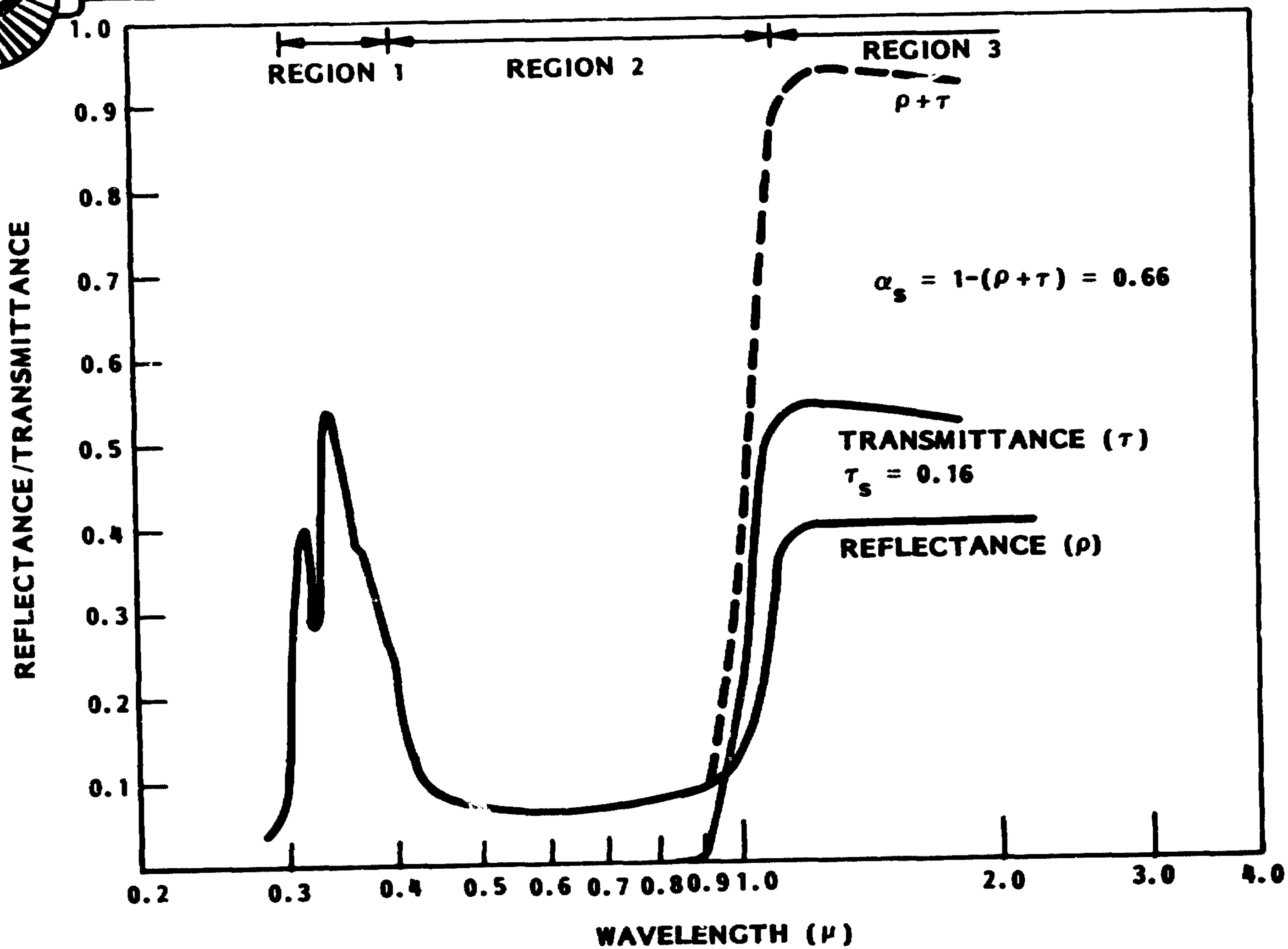
5.9 x 5.9 cm SILVER CONTACTED SOLAR CELL SPECTRAL REFLECTANCE



5.9 x 5.9 cm COPPER CONTACTED SOLAR CELL SPECTRAL REFLECTANCE



GRIDDED BACK CONTACT CELL REFLECTANCE AND TRANSMITTANCE



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REFLECTANCE CURVE — OCLI

OCLI OPTICAL COATING LABORATORY, INC.

2789 Giffen Avenue
Santa Rosa, California
Telephone (707) 545 6440

SPECTRAL PERFORMANCE

DATA IDENTIFICATION
OCLI W/O M-8411-430
Run No. various

SAMPLE IDENTIFICATION
Filter Type BSL 3 D
Material MLR Shut

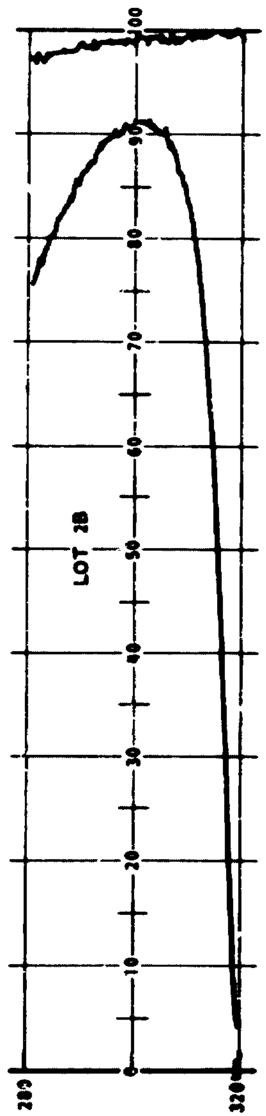
Configuration part

TEST OPERATING PARAMETERS
☐ CARY 90 ☐ IR-12
☒ CARY 14 R ☐ IR-4
☐ PE 180 ☐
Resolution 35
Scan Speed 10 Å/sec
Response 1-4
Aperture 1413
Expansion OTN2
☐ Percent Transmission
☒ Percent Reflection
☐

TEST CONDITIONS
Temp 24°C Angle 80
coated
Analyst SS

PAGE of

☐ Wavenumber
☐ Wavelength in



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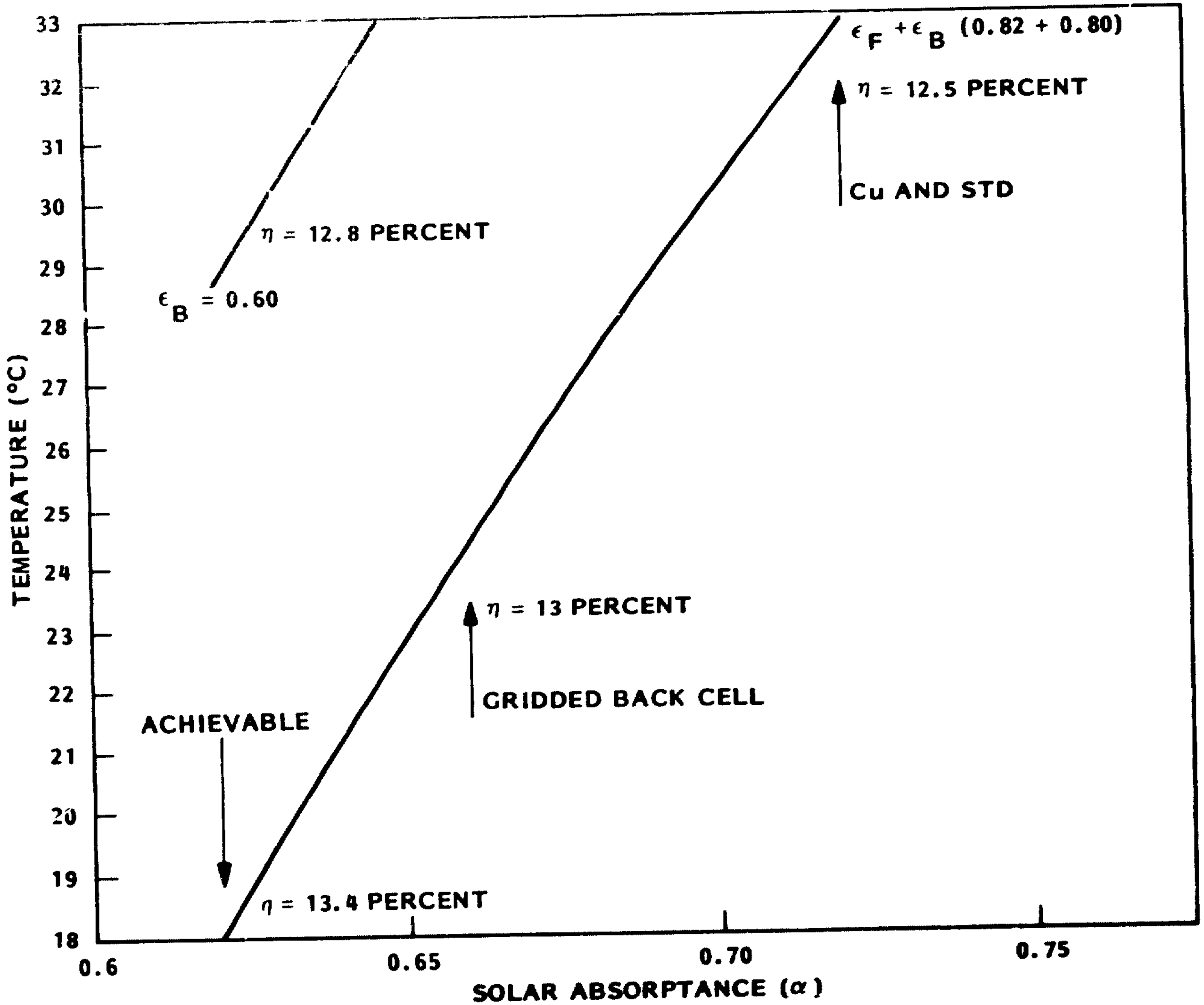
PREDICTED THERMAL PERFORMANCE VERSUS α



CLEAR THERMOPLASTIC FILM MATERIALS

POLYMER BASE	THERMAL EXPANSION COEFFICIENT (in./in.°F X 10^{-6})	MAXIMUM SERVICE TEMPERATURE (°F)	MODULUS OF ELASTICITY (psi X 10^{6})	LIGHT TRANSMITTANCE PERCENT	ULTRAVIOLET RESISTANCE
SILICONE	50	500		90	EXCELLENT
FEP	105	400	0.07	82-85	GOOD
POLYCARBONATE	38	250	0.5	92	GOOD
POLYARYLATE	40	300	3	75	GOOD
GLASS	0.35	600	17	93	EXCELLENT

ULTRAVIOLET IRRADIATION TEST — RESULTS OF VARYING LAMINATED COVER GLASS ADHESIVES

SAMPLE	GLASS BASE	ADHESIVE	GLASS CLOTH	COVER GLASS	PRETEST τ_s	POSTTEST τ_s	$\Delta\tau_s$
1	0211	-0-	-0-	-0-	0.916	0.909	0.007
2	0211	GT100	-0-	0211	0.879	0.598	0.281
3	0211	GT100	3 mil PVA GLASS	0211	0.873	0.478	0.395
4A	0211	93-500	-0-	0211	0.899	0.899	0.000
4B	0211	93-500	-0-	0211	0.899	0.898	0.001
5A	0211	93-500	7-mil PVA GLASS	0211	0.882	0.867	0.015
5B	0211	93-500	7-mil PVA GLASS	0211	0.886	0.858	0.028
5C	0211	93-500	7-mil PVA GLASS	0211	0.827	0.800	0.027
6	0211 (AR-UV)	93-500	6-mil ACRYLIC GLASS	0211 (AR-UV)	0.873	0.853	0.020
7	0211 (AR-UV)	93-500	7-mil PVA GLASS	0211 (AR-UV)	0.875	0.859	0.016
8	0211 (AR-UV)	93-500	-0-	0211 (AR-UV)	0.890	0.892	(0.002)
9A	0211	93-500	6-mil ACRYLIC GLASS	0211	0.879	0.808	0.071
9B	0211	93-500	6-mil ACRYLIC GLASS	0211	0.842	0.759	0.083
10A	0211	93-500	1.2 POLYESTER	0211	0.857	0.612	0.245
10B	0211	93-500	1.2 POLYESTER	0211	0.866	0.591	0.275

SOLAR CELL COST PROJECTIONS

		13.5 KW		0.135 KW		406 KW	
		$/cen	$/WATT	$/cen	$/WATT	$/cen	$/WATT
5.9 X 5.9	PLATED CONTACTS	70.00	119.97	50.00	85.69	50.00	85.69
5.9	GRIDDED AG CONTACTS	70.00	111.91	50.00	79.94	50.00	79.94
5.9	Cu CONTACTS	70.00	119.97	50.00	85.69	50.00	85.69
5 X 5	POLY- REG CONTACTS	7.75	22.93	7.05	20.95	6.75	19.97
	FEED THROUGH	9.70	28.70	8.80	26.04	8.45	25.00
10 X 10	POLY - REG CONTACTS	20.00	14.81	18.00	13.33	17.25	12.78
	FEED THROUGH	25.00	18.52	22.50	16.67	21.50	15.93

NOTE: 5.9 X 5.9 cm EFFICIENCY = 12.8 PERCENT
10 X 10 cm EFFICIENCY = 10.0 PERCENT
5.9 X 5.9 cm GRIDDED BACK ON-ORBIT EFFICIENCY = 13.4 PERCENT

TASK 2

- MODULE FABRICATION
- CELL AND MODULE TEST RESULTS
- 30-CELL SUPERSTRATE RESULTS

LOCKHEED MISSILES & SPACE COMPANY INC.

CELL DISTRIBUTION MATRIX

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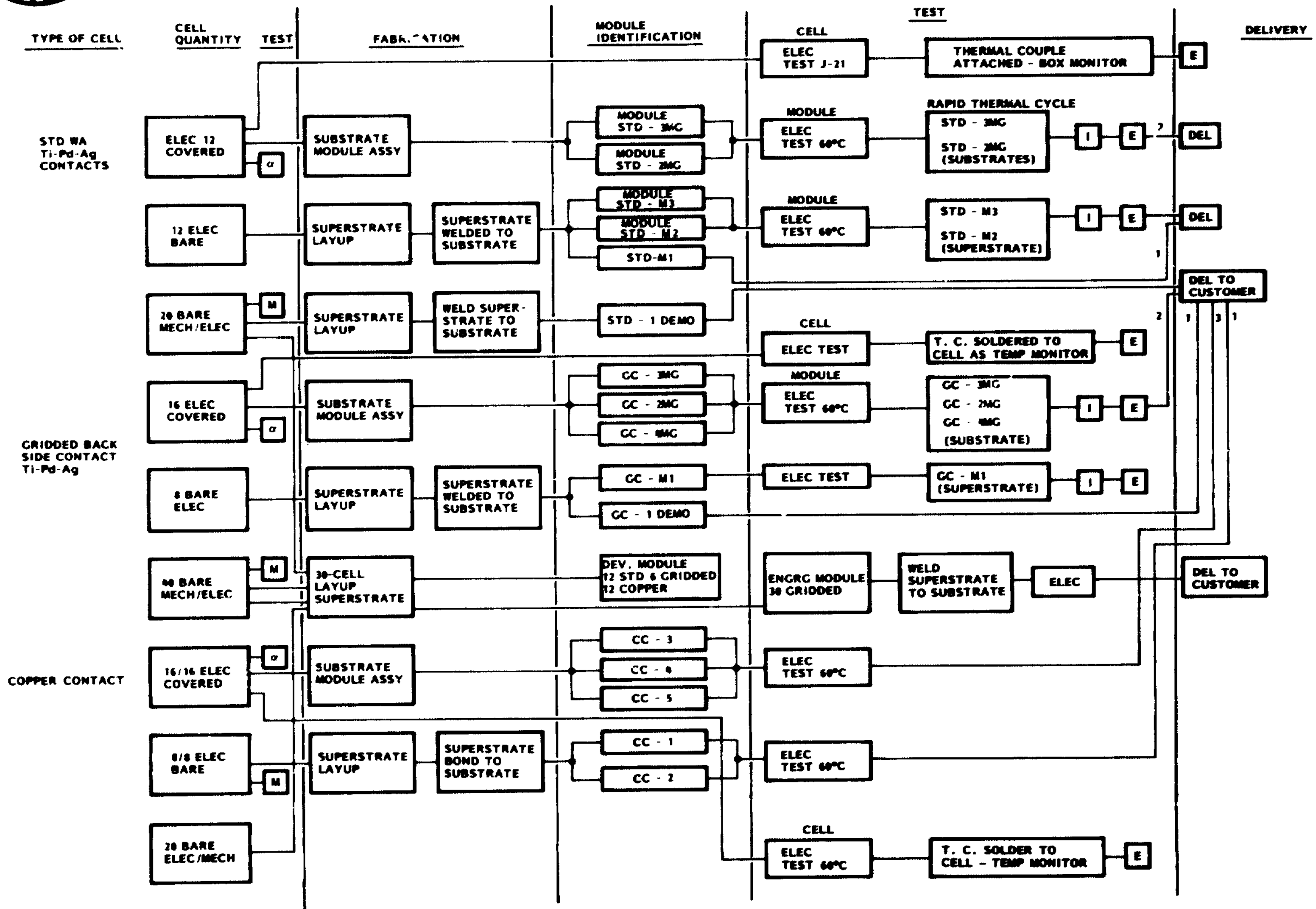


α = ABSORPTIVITY TEST M CONTACT PULL STRENGTH TEST I = INSPECTION E = ELEC TEST

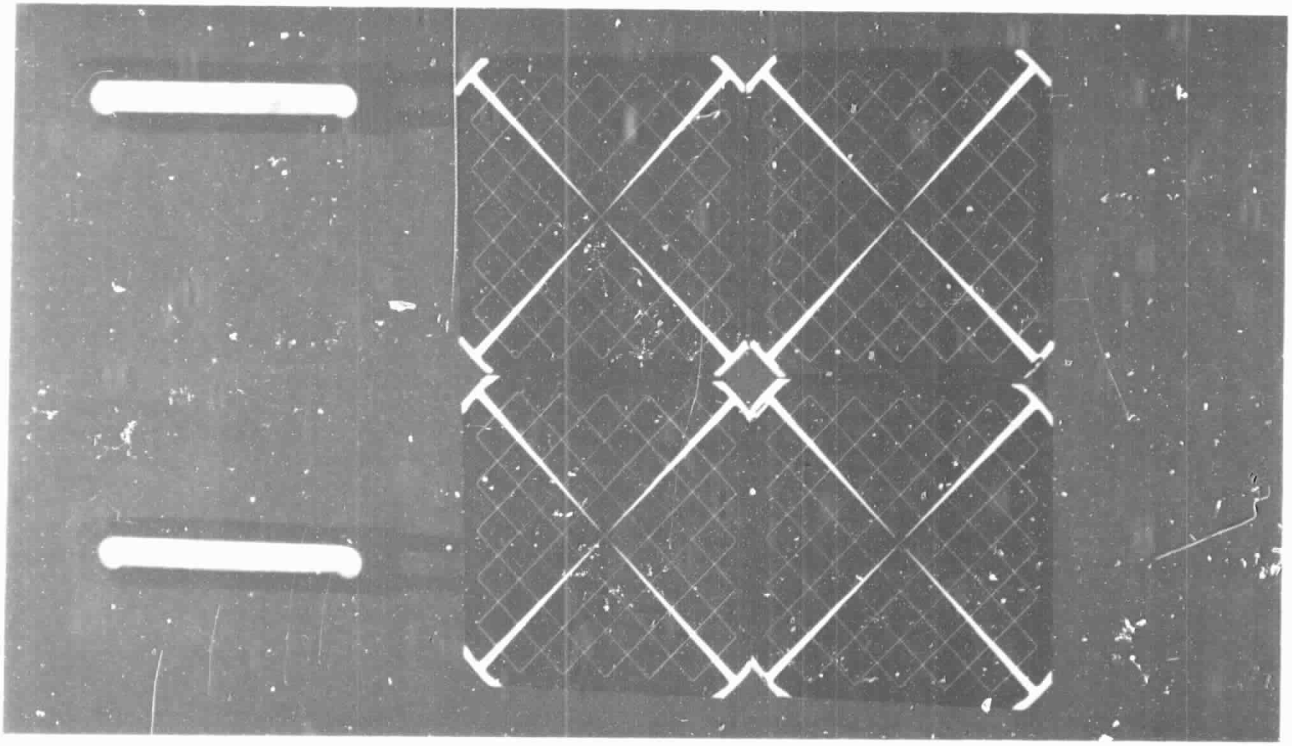
FOUR (4) CELL MODULE DESCRIPTION

MODULE NO.	TYPE OF CELL	CONFIGURATION SUBSTRATE[a]	CONFIGURATION SUPERSTATE[b]	WELDED	SOLDERED	THERMAL CYCLED	DISPLAY ONLY
STD - M1	BASELINE 2 Ω-cm BSR Ti-Pd-Ag WRAPAROUND CONTACT		X	X		NO	
M2			X	X		YES	
M3			X	X		YES	
2MG		X		X		YES	
3MG		X		X		YES	
1D			X	X		NO	X
GC - M1	GRIDDED CONTACT 2 Ω-cm Ti-Pd-Ag GRIDDED BACKSIDE WRAPAROUND CONTACT		X	X		YES	
1MG		X		X		NO	
2MG		X		X		YES	
3MG		X		X		YES	
4MG		X		X		YES	
1D			X	X		NO	X
CC - 1	COPPER CONTACT 2 Ω-cm Ti-Pd-Cu BSR WRAPAROUND CONTACT		X		X	NO	
2			X		X	NO	
3		X			X	NO	
4		X			X	NO	
5		X			X	NO	

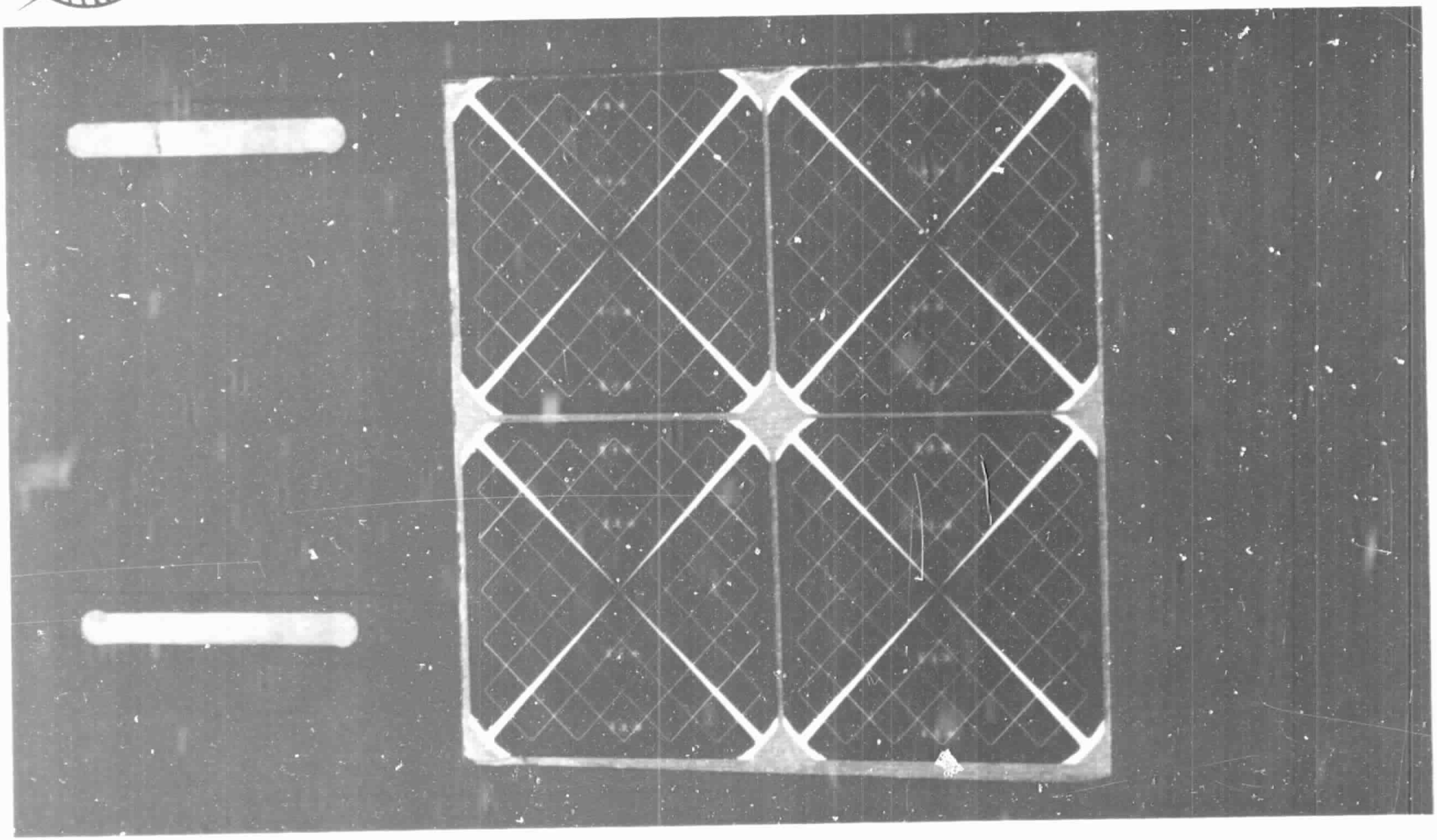
(a) INDIVIDUAL COVERS 6-mil 0211 MICROSHEETS UV AND AR COATINGS.

(b) SINGLE 6-mil 0211 MICROSHEET GLASS.

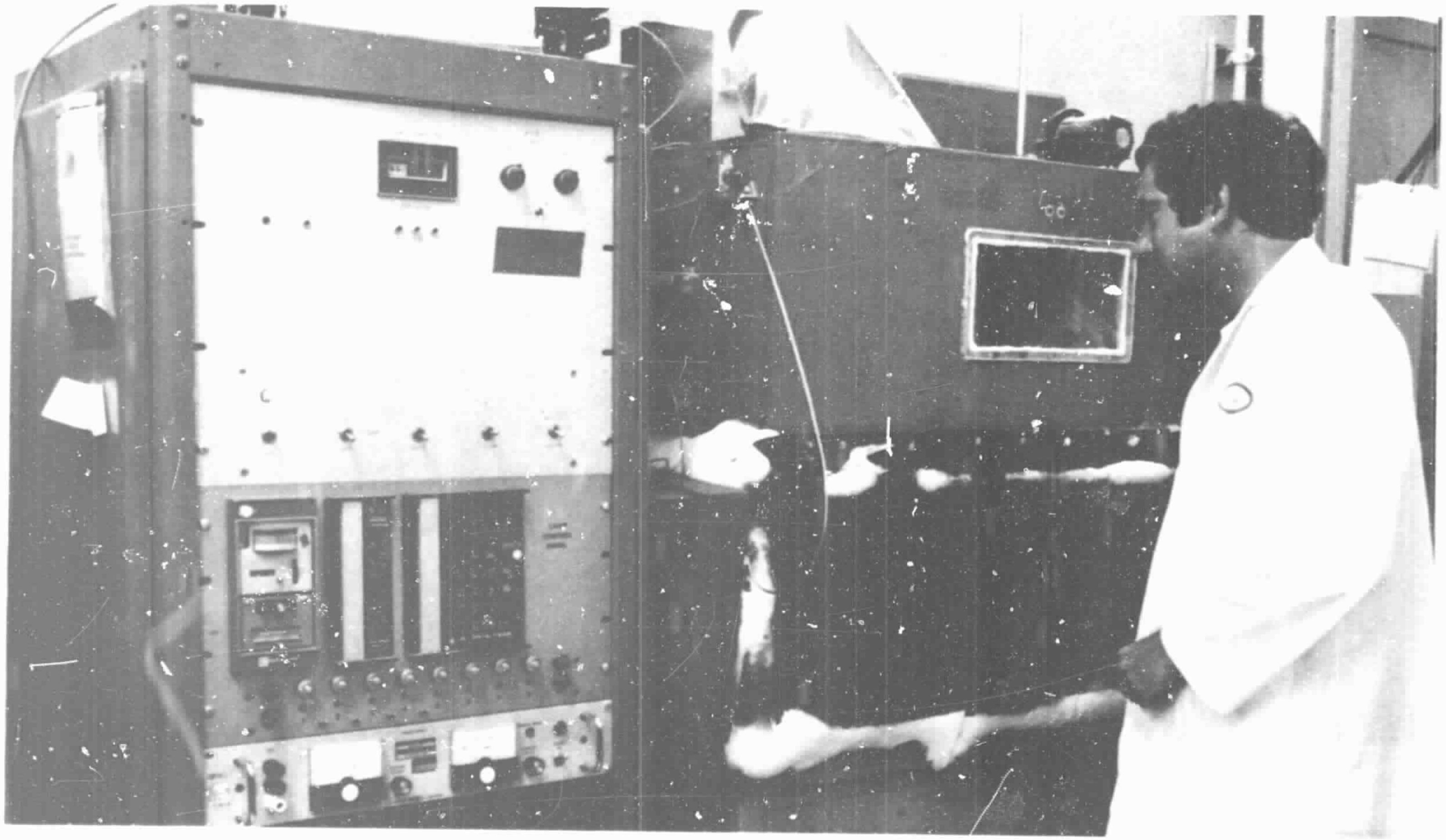
TYPICAL FOUR-CELL SUBSTRATE MODULE



TYPICAL FOUR-CELL SUPERSTRATE MODULE



QUICK-LOOK THERMAL CYCLE CHAMBER



TEST MODULE ELECTRICAL PERFORMANCE SUMMARY

MODULE DESCRIPTION	VOC		IS/C		VMP		IMP		PMP			TEMP	
	INITIAL	POST T.C.	INITIAL	POST T.C.	INITIAL	POST T.C.	INITIAL	POST T.C.	INITIAL	POST T.C.	PERCENT Δ/CHANGE	INITIAL	FINAL
STD - M1	2101.1		1241.2		1638.8		1140.3		1868.0			58.5	
M2	2121.8	1697.3	1278.1	1267.4	1676.2	1442.7	1127.4	1183.3	1889.8	1715.0	-9.2	59.9	59.1
M3	2115.4	2088.8	1271.2	1263.5	1671.2	1650.1	1115.8	1117.3	1864.7	1843.5	-1.0	59.9	60.1
3MG	2035.2	2075.4	1319.4	1307.0	1587.5	1618.8	1161.5	1161.5	1843.8	1880.2	+2.0	60.0	60.2
2MG	2156.6	2137.9	1295.2	1280.1	1660.6	1646.2	1155.2	1147.9	1918.4	1889.7	-1.5	59.9	59.9
GC - 1MG	2042.2		1305.7		1531.7		1041.8		1595.6			60.0	
2MG	2055.6	2082.6(b)	1289.7	1259.6(b)	1562.3	1478.7(b)	1042.1	1005.7(b)	1628.0	1487.1(b)	-8.7	60.2	59.8
3MG	2048.8	2089.3	1290.1	1280.7	1557.1	1504.3	1075.9	1058.5	1675.3	1592.2	-5.0	60.0	59.9
4MG	2030.0	O.C.(a)	1290.7	O.C.	1542.8	O.C.	1047.8	O.C.	1616.6	O.C.	-100.0	60.1	-0-
M-1	2023.8	2043.5(b)	1238.2	1232.7	1477.4	1410.0(b)	970.8	944.6	1434.2	1331.9(b)	-7.1	60.0	59.9
1D(c)	2947.5	2040.8	1218.3	1228.8	1535.6	1530.6	960.5	967.3	1474.9	1400.7		59.7	60.5
CC - 1	2066.8		1244.3		1488.1		1056.0		1571.4			60.2	
2	1562.1		1250.0		1124.7		1059.3		1191.4			60.0	

(a) O.C. = OPEN CIRCUITED
(b) CELL HELD IN CONTACT WITH COPPER TRACE FOR POST T.C. ELECTRICAL. NORMAL POST-TEST CONDITION WAS OPEN.
(c) DISPLAY MODULES

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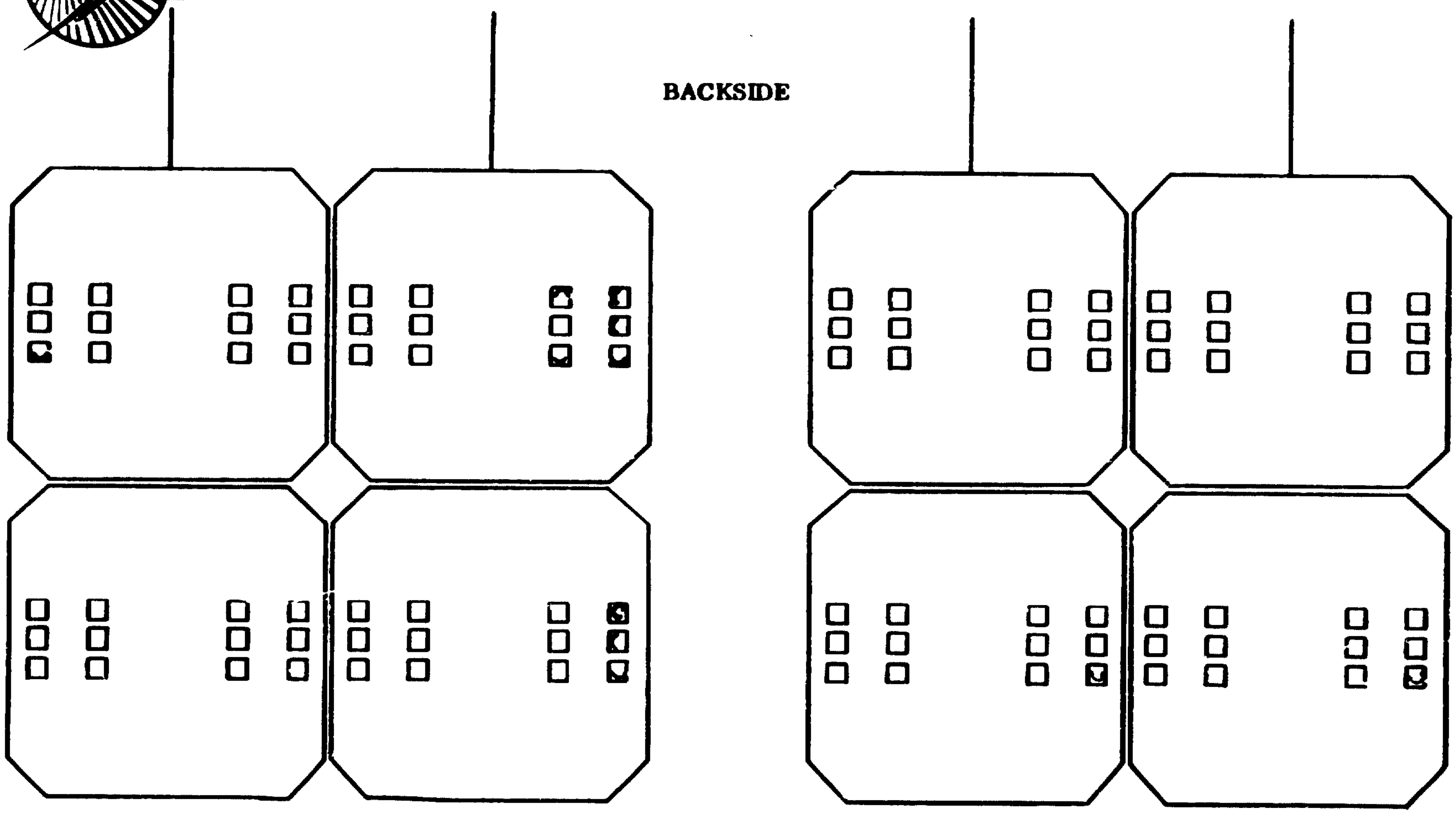
POST-THERMAL CYCLE WELD JOINT INSPECTION



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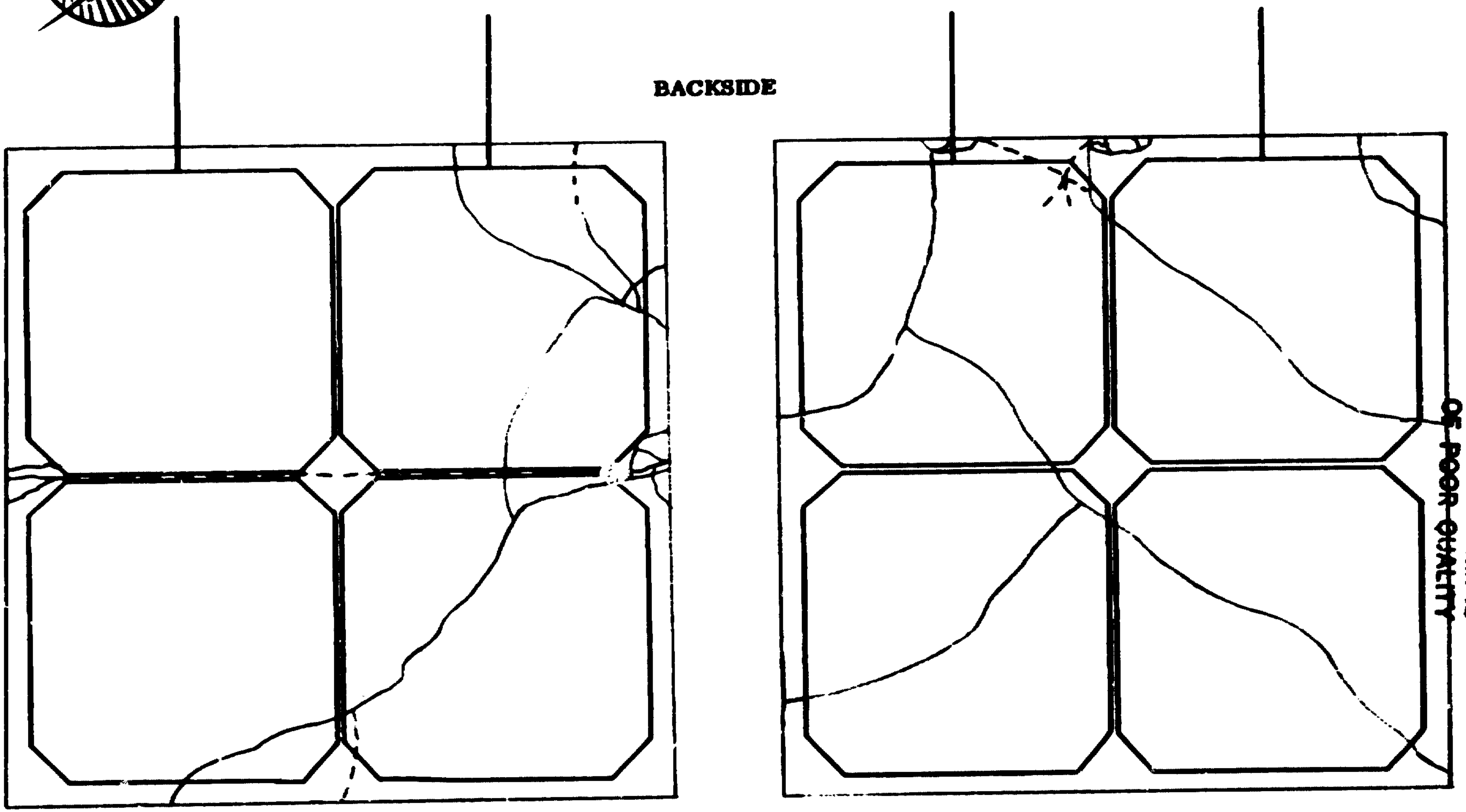
POST-THERMAL CYCLE SUPERSTRATE INSPECTION

BACKSIDE



LARGE SUPERSTRATE DEVELOPMENT

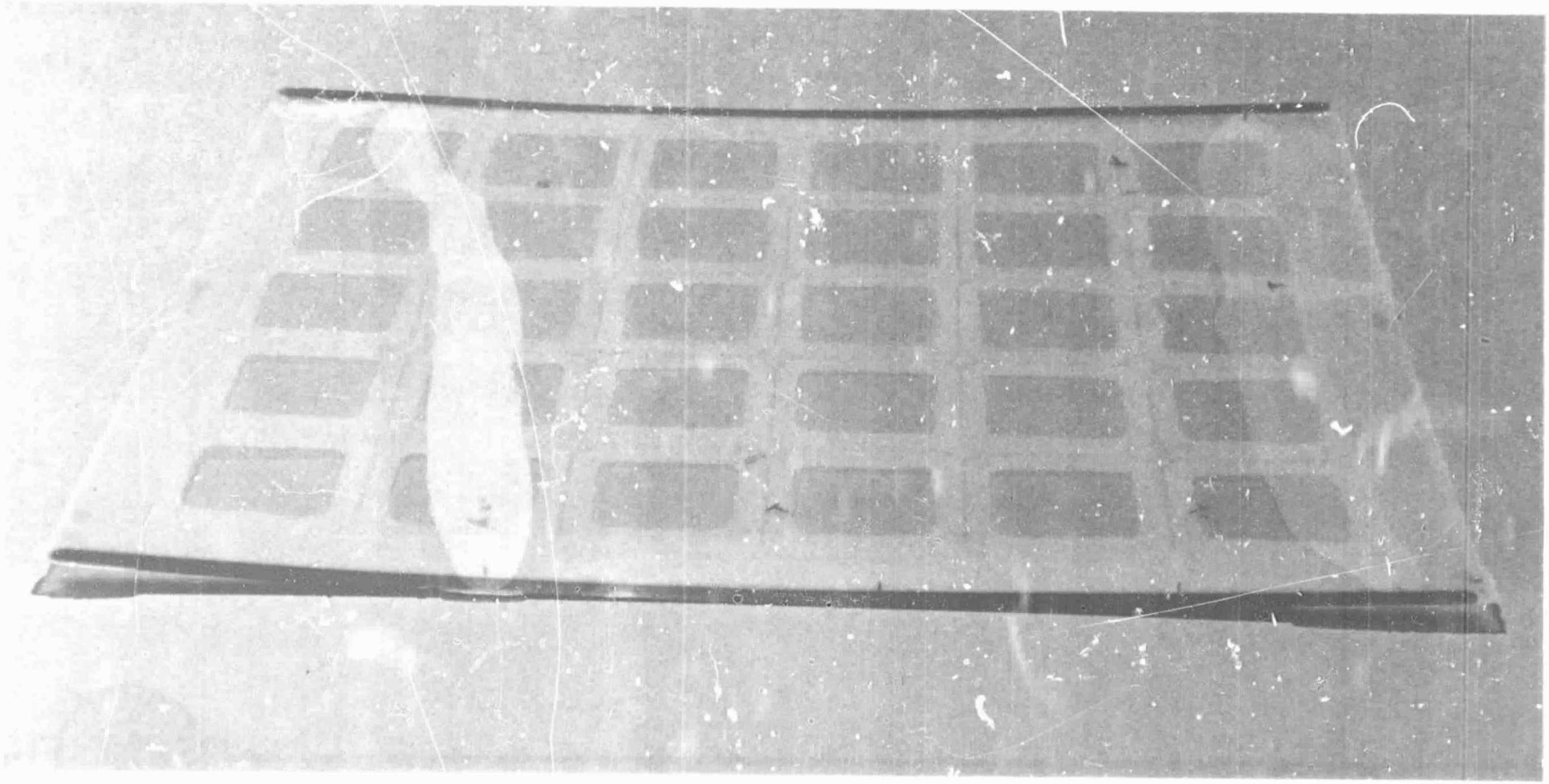
OBJECTIVE: BY FABRICATION OF LARGE MODULES, VERIFY THAT SUPERSTRATE ARRAYS ARE STRUCTURALLY VIABLE IN A REASONABLE MANUFACTURING ENVIRONMENT

DESCRIPTION:

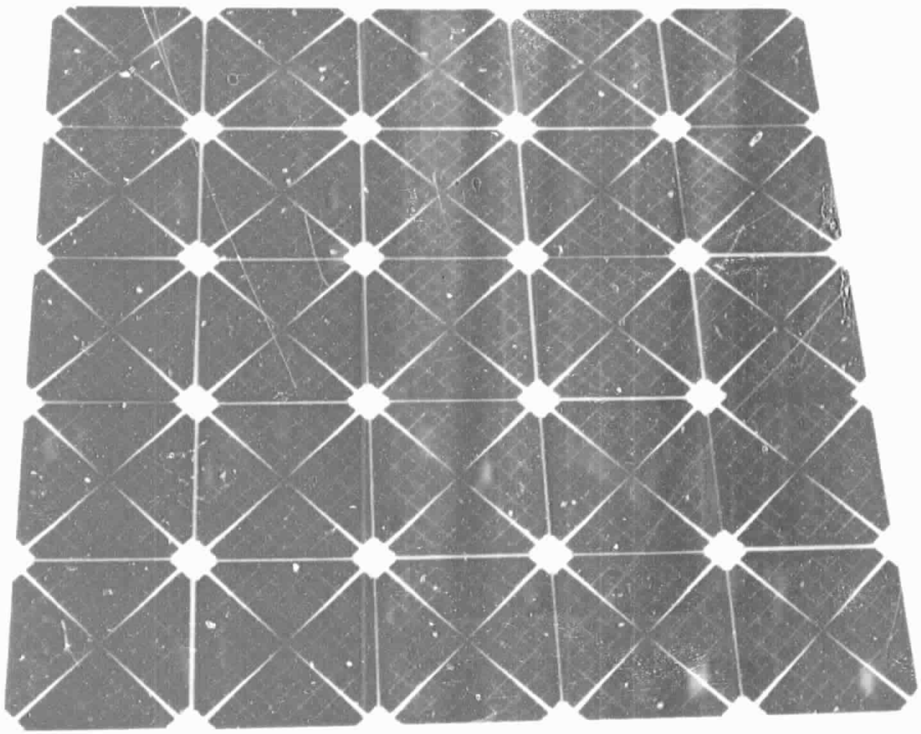
- THREE 14 X 16 X 0.009-IN. MODULES USING CORNING 0211 MICROSHEET AS A SUPERSTRATE WERE FABRICATED
  - 30M-1E 30 GLASS SIMULATORS, GRAPHITE STIFFENERS
  - 30M-2E 12 STD, 6 GRIDDED, 12 COPPER CELLS S-GLASS STIFFENERS
  - 30M-3E 30 GRIDDED BACK CELLS DELIVERABLE TO MSFC

COMPLETED DEVELOPMENT MODULE

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



30-CELL SUPERSTRATE MODULE (14 by 16 in.)



CONCLUSIONS

ALTERNATE CONTACT CONFIGURATION/METALLIZATION

- GRIDDED BACK CONTACT CELLS HAVE SHARPLY REDUCED SOLAR ABSORPTANCE (~0.62 ACHIEVABLE) WITH NEGLIGIBLE ELECTRICAL DEGRADATION
- COPPER CONTACTS WILL REQUIRE A DEVELOPMENTAL PROGRAM BEFORE A SUCCESSFUL INTERFACE IS ACHIEVED
- GRIDDED BACK CONTACT CELLS USING Ti-Pd-Ag AS THE CONTACT MATERIALS APPEAR TO BE THE MOST COST-EFFECTIVE DESIGN AT PRESENT YIELDING A 7 PERCENT PERFORMANCE ADVANTAGE AT A CELL COST OF LESS THAN $80/W.

SUPERSTRATE VERSUS CONVENTIONAL

- LARGE-AREA SUPERSTRATES OF UP TO 30 CELLS USING 9-MIL MICROSHEET HAVE BEEN SHOWN TO BE FEASIBLE.
- THE MAJOR PROBLEM ASSOCIATED WITH THE SUPERSTRATE IS CRACKING DUE TO EDGE DEFECTS.
- MECHANICAL INTEGRITY WAS MAINTAINED THROUGH THERMAL CYCLING.
- A SUBSTITUTE SHEET ADHESIVE DOES NOT APPEAR TO BE COMMERCIALLY AVAILABLE.

RECOMMENDED FOLLOW-ON TECHNOLOGY

- CONTINUED SURVEILLANCE AND EVALUATION OF LARGE-AREA CELLS OF SINGLE AND POLYCRYSTALLINE STRUCTURE AND ADVANCED PROCESSING METHODS, SUCH AS HEM, WEB AND RIBBON THAT ENHANCE COST REDUCTION.
- SUPERSTRATE GLASS OPTIMIZATION BY FURTHER EVALUATION OF MATERIALS, THICKNESS, COATINGS, AND SIZE LIMITATIONS. DEVELOP METHOD OF CUTTING AND ANNEALING GLASS EDGE.
- INVESTIGATE SUPERSTRATE BONDING SYSTEMS THAT ARE COMPATIBLE WITH LEO THERMAL AND OPTICAL REQUIREMENTS
- DEVELOP AN INTERCONNECT SYSTEM OPTIMIZED FOR THE SUPERSTRATE CONCEPT WITH THE INTENT OF ELIMINATING THE KAPTON-COPPER SUBSTRATE
- CONDUCT MECHANICAL AND ENVIRONMENTAL TESTS TO CONFIRM ANALYTICAL THEORIES